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*DECEMBER—1897*

THE PRODUCTION OF GOLD SINCE 1850.

THE statistics of gold production are unreliable. Much of the output is never reported to the officials.<sup>1</sup> There is a chance of error in converting "rough gold" or "unrefined bullion into fine gold."<sup>2</sup> Where exports are the only register of production, minted gold and gold ornaments are frequently included in the estimates of fresh production.<sup>3</sup>

For the purposes of this discussion the table of gold production compiled by Richard Rothwell for the *Mineral Industries* has been taken,<sup>4</sup> since they are on the whole least liable to error. These figures for production, reduced to percentages, are represented in the accompanying chart. The movement of production may be separated into two periods. From 1853 to 1883 the general tendency is downward. The production declines 38.4 per cent. Beginning with 1884, the line rises rapidly, standing in 1896 at 320.4 per cent. above the production of 1850.

To show the effect of the demand for gold upon its production, variations in its value may be compared with variations in the product. For the greater ease of comparison, the value of gold in terms of general commodities is represented in the same chart with the production figures. This expression of the value

<sup>1</sup> *Eleventh Census, Mineral Industries*, pp. 40–57.

<sup>2</sup> *Report of the German Monetary Commission*. Sessions 17 to 20, pp. 6, 7.

<sup>3</sup> The reported gold production of China has been discredited on this ground.

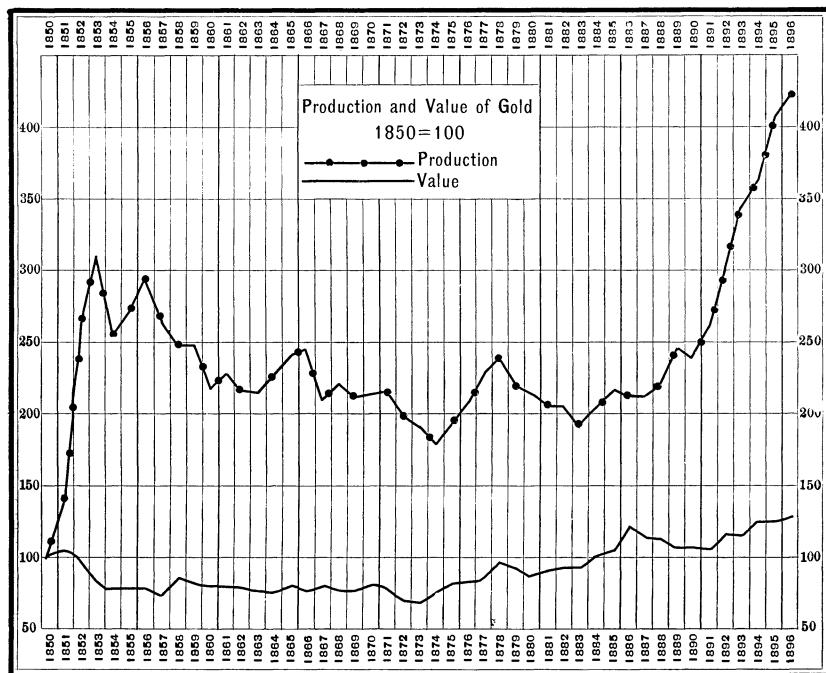
<sup>4</sup> ROTHWELL, *Mineral Industries of the United States*, 1895 and 1896.

of gold for the period in question is obtained by taking the reciprocals of Sauerbeck's index numbers,<sup>1</sup> and reducing them to percentages on the same basis as the figures of production. An examination of the line for the value of gold shows (1) that, with the exception of the years 1872 and 1873, it remained tolerably constant from 1853 to 1878, and (2) that from 1876 it rose rapidly standing at 124.2 per cent. in 1895. To express this movement in terms of demand, there was a stable demand for gold from 1853 to 1876, and an increasing demand from 1876 to 1895.

It appears that the production of gold, during the greater part of the period, does not correspond to the course of its value. From 1851–1855 the production decreased though the value remained approximately constant, and it increased from 1876 to 1884. Since 1884 the supply has shown an increasing correspondence with the value movement. Generally speaking, a constant or increasing value of any commodity is accompanied by an increasing production. The main purpose of this study is to explain the exception to this rule which appears in the production of gold.

Gold occurs in two general forms of deposit: veins and placers; more accurately, primary and secondary formations. Like other metals, it occurs throughout the earth. The manner of its deposit in veins is much the same as that of other metals. Fissures occur in the earth's crust. Water passes through the surrounding rocks and penetrates these fissures. The water takes into solution a part of the mineral contents of the rocks through which it passes, gold along with the rest. In the lower

<sup>1</sup> This formula for expressing the value of gold in terms of commodities was explained in this *JOURNAL* for March 1897, pp. 245–249. It should be noted that these index-numbers are, to a degree, untrustworthy, since they relate chiefly to raw materials, and therefore do not fairly show the increased value of gold as compared with manufactured products. These have been affected in supply by the progress of invention to a greater extent than the products of extractive industry. On the other hand, the London market, from which these prices are taken, is an exceptionally staple market, and the estimates are satisfactory in that respect, as also in that they are continued down to the present.



For table of figures on which this chart is based, see Appendix, p. 138.

levels the water becomes heated and dissolves larger quantities of metals. This impregnated water frequently returns toward the surface through fissures which offer an easy passage, and as it rises and cools, it deposits its mineral contents upon the sides of the fissures.

Gold preserves its identity in an exceptionally high degree, as it does not readily enter into chemical combination with other substances ; owing to its high specific gravity, it occurs in much smaller quantities than most of the other metals ; and it is extremely insoluble. These facts account for its scarcity, and for the relative difficulty of discovering gold in any considerable quantities. This difficulty is increased by the absence of color compounds, such as are so important a factor in the discovery of iron ore. The irregularities of the deposit, although in proportion to the gross amount they are no greater than in the case of iron, lead, or copper, are of far greater economic significance in the case of gold, because of its greater value.<sup>1</sup> Much the greater quantity of gold occurs below the water line. Above that point it has been freed from other substances by the action of water and oxygen. Below the water line, however, the presence of foreign substances greatly complicates the problem of extraction.<sup>2</sup> The difficulties to be met in gold mining under these circumstances are evidently considerable. The ore must be mined, often at great depths. It must then be sorted, crushed, stamped, and amalgamated with mercury. Special processes are necessary to treat gold ores which contain sulphur, or certain other substances. A large amount of capital and a high order of engineering skill are required in this work.

The extraction of gold from the secondary, or placer, formation is much more simple. The gold-bearing rocks have been disintegrated by the action of water, and the resulting detritus carried down into the beds of streams. Here the steady action

<sup>1</sup> A 10 per cent. fluctuation in the yield of a vein of lead at an average value of 3 cents per pound, is evidently of less consequence than a similar variation in the yield of gold, which brings \$20.00 per ounce.

<sup>2</sup> EISSLER, *Metallurgy of Gold*, p. 4.

of running water separates the gold from the lighter minerals associated with it, by wearing them away and carrying them farther. The heavier metal lodges, frequently in large quantities, at the bars or riffles, wherever its progress is at all impeded. It is also scattered finely through the sands which form the beds of these streams. In this way the gold is almost entirely freed from foreign substances, and it usually lies at no great depth. Placer deposits are easily discovered and can be easily and rapidly worked. The miner's work consists merely in the further application of running water to the gold-bearing sand and gravel. The necessary implements are few and simple, and they are operated mainly by manual labor and require little skill in their use.<sup>1</sup>

Before 1850, vein mining, generally speaking, was not practiced. Practically all of the gold produced in the world since the discovery of America had been obtained from placers.<sup>2</sup> The pan and cradle were the tools in general use. Beginning with 1849 came a series of important placer discoveries in California and Australia. The working of these fields was pushed vigorously by thousands of miners with the primitive tools of the period, and the production rose to unprecedented figures. The year of greatest production in California was 1851, when gold to the amount of 81 million dollars was taken out. The same year witnessed the first attempt to work the quartz veins which are always associated with placers. From this time there was a steady decline in production; while the placers were being exhausted and the quartz mines opened. The production of California reached its lowest point in 1892, when it stood at 12.0 million dollars. In 1896 it had increased to 15.2 million dollars.

In 1851, the entire production was obtained from the alluvial deposits; in 1881 one-half was alluvial, and in 1892 10 per cent.

The average annual production of Australia, from 1852 to

<sup>1</sup> For the facts cited, see J. W. LOCK, *Practical Gold Mining*; T. EGGLESTON, *Metallurgy of Gold, Silver, and Mercury*; J. H. PHILLIPS *Ore Deposits*.

<sup>2</sup> LOCK, *Practical Gold Mining*, p. 156.

1860, exceeded two million ounces. The maximum of 3,150,121 ounces was reached in 1853. The rich alluvial deposits were rapidly exhausted and a decline began. By 1883, the production had fallen to \$26,970,836. In 1895 it stood at \$42,793,824. Vein mining in Australia began very slowly. The first attempt was made in 1857. In 1889, the ratio of alluvial to quartz production was as 37 to 63, in 1892 as 31 to 69.<sup>1</sup>

The gold production of Russia, until recent years, came entirely from placers. As the fields were exhausted the area of production has been sustained only by the constant exploitation of new fields.<sup>2</sup> The transition to vein mining has been in progress since 1882.<sup>3</sup>

In other gold producing localities the yield is obtained chiefly from vein mining.<sup>4</sup> The world must hereafter look mainly to the primary deposits for its gold supply.

The foregoing discussion explains the lack of correspondence between production and gold value for so long a part of the period under examination. Before 1850, the gold supply had been drawn from the placers with the simple tools and the small investment of capital which this form of extraction required. Beginning with 1849, came a series of rich discoveries followed by a rapid exhaustion of the placers. The quartz was then attacked. This form of production presented entirely new problems to the miner. The quartz must first be discovered, and this itself is difficult; new processes and new machinery must be invented. This abrupt transition to a new form of production was difficult, and some time elapsed before the exigencies of the

<sup>1</sup> The facts of the relative yield of quartz and placer mining in California and Australia are mainly taken from an article by MR. T. A. RICKARD, in the *Engineering Magazine*, vol. viii. p. 313. See also ROTHWELL, *Mineral Industries*, 1892, p. 192; LOCK, *Practical Gold Mining*, p. 57; *Eleventh Census, Vol. Mineral Industries*, p. 57; *Report of the Director of the Mint on Precious Metals in the United States*, 1894, pp. 193-197; *Engineering and Mining Journal*, vol. l. p. 310.

<sup>2</sup> ROTHWELL, *Manual Industries*, 1892, p. 203. *Ibid.*, 1894, pp. 590-591.

<sup>3</sup> *Ibid.*, 1892, p. 203, 1895, p. 659.

<sup>4</sup> The most important are, South Africa, Colorado, Dakota, and northern South America.

new situation were met. During the interval, in spite of the sustained demand for gold, its yearly production declined materially. After these difficulties were mastered, the increasing demand for gold called forth an increasing supply which has continued to the present.

The transition to quartz mining and the subsequent increase in production was the result of three forces: 1. A rising value of gold. 2. A progressive series of gold discoveries. 3. A considerable advance in the methods and machinery of gold extraction.

The considerable advance in the value of gold in recent years has been equivalent to a decreasing cost of gold production, since it has increased the purchasing power of the product over the instruments of its production. If we assume, as an extreme, that there has been a fall in gold prices of 42 per cent. from 1864 to 1895, the implication is that the gold miner who produced one-quarter ounce per day in 1895 has the same command over general commodities as a daily production of seven-twentieths ounce gave to the miner of 1864. As has been shown above, gold mining has required an increasing amount of capital to be invested in buildings and machinery. Large sums must also be paid for wages. The increasing value of gold has cheapened materials and machinery, and its tendency is also to lower money wages. If the supply and demand of labor remain constant this fall in money wages is inevitable.<sup>1</sup>

The average profits in gold mining have tended to rise; larger amounts of capital have been attracted into the business of gold extraction; and, as a result, new mines have been opened, and it has been possible to go on working mines of diminishing productiveness. We are safe in affirming that the recent increase in gold production has been to a large extent dependent on the fall in prices, and that even before the

<sup>1</sup>"It is a well-known fact that the average day wages paid in mining throughout the western states have largely declined, owing to the reduced cost of living. . . ."—*Eleventh Census: Mineral Industries*, p. 35.

increase began the same influence was operating in retarding the decline.

Closely connected with the increasing value of gold has been a progressive activity in prospecting. The element of discovery, as we have seen, is of prime importance in this branch of mining. A powerful stimulus is necessary to lead men to undertake so doubtful a business as the search for gold. The stimulus is supplied by a high value of gold, and it grows stronger as the value increases. It is true, discovery is largely a matter of chance; most of the finds have been the results of accident. It needs no argument, however, to prove that a thousand men searching for gold in a particular district have more chance of finding it than have five hundred gold seekers. In this way also the steady advance in the value of gold has operated to increase its production by increasing the prizes of success and of the number of prospectors. Before 1883, with the exception of some placer discoveries in Montana and Australia, few important discoveries had been made since 1862.<sup>1</sup> Prospecting activity was in the main unsuccessful. The declining production seemed to justify the predictions of an approaching gold famine, when the world's stock of coin must be drawn upon to supply the industrial demand.<sup>2</sup> But the value of gold continued to advance, and the search for gold became increasingly vigorous. This finally resulted in a remarkable series of discoveries. In 1883 production began at the Mount Morgan mine in Queensland.<sup>3</sup> In 1886 the Transvaal production began, in a district which had been unsuccessfully explored for twenty years preceding.<sup>4</sup> The mines of western Australia were opened in the following year,

<sup>1</sup> ROTHWELL, *Mineral Industries*, 1892, p. 127.

<sup>2</sup> This belief in an impending scarcity of gold is emphasized by SUÈSS in *The Future of Gold*, published in 1879. It also appeared in the discussions of the international monetary conferences of 1878 and 1881.

<sup>3</sup> See ROTHWELL, *Mineral Industries*, 1892, pp. 191, 192.

<sup>4</sup> Gold was first discovered in the Transvaal in 1867. The rush to the mines began in 1872, but by 1877 mining enterprise was at a standstill. An excitement in 1882 was followed by a collapse. In 1884, after prolonged efforts, rich discoveries were made in the De Kaap district, and in 1885, in the Witwatersrand.—ROTHWELL, *Mineral Industries*, 1892, p. 204.

after a series of failures.<sup>1</sup> A new era of production soon afterward began in the United States. The general business depression, and particularly the fall in the price of silver, stimulated the search for gold. Rich deposits were discovered in Colorado in ground which had already been thoroughly prospected for silver,<sup>2</sup> and the other gold producing states increased their yield. The laws against hydraulic mining were repealed in 1892.<sup>3</sup> Renewed prospecting activity was rewarded with rich finds in eastern Canada.<sup>4</sup> In 1894 came a series of gold discoveries in

<sup>1</sup>*Report of the Director of the Mint on Precious Metals in the United States, 1894*, p. 177.

<sup>2</sup> For an account of the Colorado discoveries see ROTHWELL, *Mineral Industries*, 1893, p. 325 (*Gold Resources of Colorado*, by T. A. RICKARD). See also U. S. Geological Survey, *Sixteenth Annual Report*, Part 2; *Geology and Mining Industries of the Cripple Creek, Colorado*, by WHITMAN CROSS and R. A. F. PENROSE, JR. ROTHWELL, *Mineral Industries*, 1893, p. 312, "Men thrown out of work by the closing down of the silver mines engaged in rewashing the gravel of old placers, in order to earn their living, while capitalists reopened old or low grade mines which had been neglected for many years in consequence of the greater possibilities in silver mining. Prospecting for gold was also stimulated and important discoveries were made."

TABLE SHOWING THE PRODUCTION OF GOLD IN FINE OUNCES BY STATES AND TERRITORIES IN THE UNITED STATES, 1890-1896, COMPILED FROM ROTHWELL, "MINERAL INDUSTRIES," 1895, 1896, AND FROM THE "REPORTS OF THE DIRECTOR OF THE MINT."

States and Territories	1890	1891	1892	1893	1894	1895	1896
Alaska .....	36,886	43,537	48,375	48,863	53,868	78,140	99,444
Arizona .....	48,375	47,166	51,761	57,286	86,324	95,072	124,770
California .....	604,687	609,525	580,500	584,370	656,468	722,171	737,036
Colorado .....	200,756	222,525	256,387	364,119	459,152	648,074	719,264
Idaho .....	89,494	81,270	83,271	79,669	100,682	86,088	104,263
Montana .....	159,638	139,804	139,871	172,989	176,637	198,405	209,207
Nevada .....	135,450	99,169	76,021	46,367	55,042	75,088	116,620
Utah .....	32,895	31,444	31,936	41,293	41,991	66,419	91,908
South Dakota	154,800	171,731	178,987	193,809	159,594	187,187	237,978
New Mexico.	41,119	43,779	45,956	44,171	27,465	50,894	23,017
Oregon .....	53,213	79,335	67,725	79,592	68,792	39,918	59,513

<sup>3</sup>This kind of mining had been prohibited since 1882. By the law of 1892 operations could be resumed where the streams could be protected from the débris.

<sup>4</sup>*Report of the Director of the Mint on the Production of the Precious Metals in the United States, 1894*, pp. 217-219. See also *Report of the Geological Survey of Canada: Department of Mineral Statistics and Mines, 1890*, pp. 55 et seq.

British Columbia.<sup>1</sup> The Australian business depression increased the prospecting activity, and the discoveries in that country.<sup>2</sup> New gold fields have been opened in South and Central America,<sup>3</sup> and finally, in the last two years, rich finds are reported in Alaska, and active work is there in progress.

These discoveries have come in an accelerating series, answering to the increasing value of gold, and<sup>4</sup> they have been

<sup>1</sup> ROTHWELL, *Mineral Industries*, 1896, p. 248.

TABLE OF GOLD PRODUCTION IN BRITISH COLUMBIA.

Year	Production, fine ounces
1891	429,811
1892	399,526
1893	379,535
1894	530,530
1895	1,266,954
1896	1,788,206

<sup>2</sup> TABLE OF INCREASED GOLD PRODUCTION IN AUSTRALASIA.

Year	West Australia	New South Wales	Victoria	New Zealand	Queensland
1890	22,806 oz.	127,760	588,560	193,193	610,587
1891	30,311	153,336	576,399	251,996	576,439
1892	59,548	156,870	654,456	238,079	615,550
1893	110,891	179,288	671,126	226,811	616,970
1894	207,131	324,787	673,680	221,533	679,511
1895	188,683	315,144	695,681	264,142	511,313
1896	251,646	259,063	756,782	234,352	526,525

See also ROTHWELL, *Mineral Industries*, 1894, 1895, 1896; and *Report of the Secretary of Mines for Victoria*, 1893, quoted in *Report of the Director of the Mint*, 1894, p. 180: "Attention has been turned to old gold fields, where years ago rich quartz was mined, but which have been neglected, and in some cases almost forgotten. . . . In addition to this a large amount of prospecting is being done in all parts of the colony resulting in new discoveries being made from time to time." "Much enterprise has been shown during the last few years in the search for gold, and many new mines have been opened up."—*Ibid.*, pp. 193-197.

<sup>3</sup> *Report of the Director of the Mint on the Production of the Precious Metals in the United States*, 1894, pp. 227, 238; ROTHWELL, *Mineral Industries*, 1895, p. 634; *Engineering and Mining Journal*, vol. lix. p. 339.

<sup>4</sup> It is to be noted that prospecting has now become an art, proceeding according to certain definite rules. A knowledge of the characteristics of a district is of great use in gold discoveries therein.

accompanied by a series of important improvements in methods and appliances. The improvements made may be discussed under two heads: placer mining, and vein mining. Though placer working is relatively easy, it presents many difficulties after the rich alluvium of the river bars has been exhausted. The gradual exhaustion of the bars has forced the miner to improve his methods in order to profitably extract the gold which lies finely scattered throughout the sands of the river beds. The gold is sometimes found under a thick mass of worthless surface materials. In the case of deposits in old river beds, this covering is frequently hundreds of feet in thickness. Rich placers are also sometimes exposed in the dry beds of streams out of convenient reach of water. Where the gold occurs in clay deposits it cannot be treated by the ordinary processes.

The principal appliances for placer working are the cradle and the "sluice."<sup>1</sup> The capacity of these appliances has been greatly enlarged.<sup>2</sup> Great improvements have been made in appliances for pumping out workings<sup>3</sup> and for bringing the gold-bearing earth to the head of the sluice, and powerful steam dredges are employed to strip the gold deposits where these

<sup>1</sup> The cradle is a box set on rockers, in which the gold bearing gravel is disintegrated by mixing with water and rocking. The sluice consists of an inclined channel through which flows a stream of water. Into this channel the gold bearing earth is thrown, the water carrying away the worthless material and cleaning the gold. Cf. LOCK, *Practical Gold Mining*, pp. 157, 169.

<sup>2</sup> For the "blanket" and apron of the cradle, and in place of the flat strips of wood or riffles placed on the bottom of the sluice box, has been substituted a riffle box. This is formed of shallow compartments filled with mercury. It takes up a much larger proportion of the gold. This has in its turn been supplanted by copper plates covered with nitrate of mercury to which the gold adheres. Multiple sluices enable washing to proceed without interruption, one section being cleaned up while the other is working. The under-current sluice is inserted under the last box of the main sluice which is provided with an iron grating. The large and coarse material passes out while the fine matter containing most of the gold enters the lower sluice, which, with a slower current, catches much of the gold that would otherwise be lost. *Ibid.* pp. 159, 169, 180, 181.

<sup>3</sup> Water in alluvial workings was primarily pumped out by hand. The present method is by chain pumps worked by water or steam power, or by large siphons. As the workings went deeper; the "pay dirt" was thrown by hand up a series of stages.

occur at a moderate depth.<sup>1</sup> For working the dry placers, which occur extensively in South America, Australia and Siberia, various machines have been invented to meet the deficiency of water.<sup>2</sup> Puddling machines have been invented for working gold found in connection with clay. These are in large use in Australia, where water is not available for hydraulic mining.<sup>3</sup> For extracting the gold scattered throughout the river beds the principal methods introduced in late years, are "river lifting" and dredging.<sup>4</sup> Wing dams have also been employed.<sup>5</sup>

The most important advance in the extraction of gold from the secondary formation has been the discovery and improvement of the methods of hydraulic mining. This merits some more detailed description, both on account of its past importance, and because it will probably take the place of many of the simpler methods now in vogue for placer working. The "drifts" of the western slopes of the Sierra Nevada range have already been mentioned.<sup>6</sup>

The gold occurs very irregularly in these drifts. If this gold was to be extracted, some method of rapidly handling large

This has been superseded by various devices worked by horse or water power, by which the earth is rapidly conveyed to the surface in buckets. The latest improvement in this appliance is a cable tramway worked by steam power. *Ibid.*, pp. 186, 188, 190.

<sup>1</sup> *Ibid.*, p. 190; and *Engineering and Mining Journal*, Nov. 20, 1897.

<sup>2</sup> One of these substitutes a pulsating blast of air for a stream of water. Another device throws the gold bearing dirt by centrifugal action against a wall of mercury. *Ibid.*, pp. 197-198.

<sup>3</sup> *Ibid.*, pp. 182 *et seq.*

<sup>4</sup> In "river lifting" the stream is allowed to flow over a flume beneath which the exposed bed is washed for gold. Streams have thus been "lifted" for a distance of one-half to three-fourths miles.

The steam dredge is in large use in New Zealand, where large quantities of gold have been obtained by this means. In its most common form it consists of a series of scoops running on an endless chain, and carrying the sand to the head of the sluices. A suction pump dredge has also been used. *Ibid.*, p. 201, *Transactions A. I. M. E.*, vol. xxi, p. 453.

<sup>5</sup> Parallel dams are built. The water above the first dam is allowed to flow through a flume below the second, while the space between the dams is pumped dry. *LOCK, ibid.*, p. 201.

<sup>6</sup> Page 10 above.

quantities of material must be devised. This method was found in the hydraulic process. In this process, water is thrown against the gravel banks in large volume and under high pressure, supplied from reservoirs high above the point where the washing is done. The banks are first shaken by powder blasts, and when the water is turned against them, the gravel is torn down in large quantities and washed through a long line of sluices, and much of the gold is caught on the riffles of the sluice boxes. The machinery consists (1) of pipes of sufficient size and strength to convey water under high pressure against the bank which is being attacked, and (2) of a system of reservoirs, ditches, and flumes to hold and convey the water.<sup>1</sup> In the early development of hydraulic mining much loss was sustained in the destruction of flumes and ditches by floods, and from an intermittent flow of water. These difficulties have been met by improved construction.<sup>2</sup>

An important modification of the original process is the hydraulic elevator. This is used to exploit the flat beds of alluvium which it is not possible to treat by the ordinary methods. It consists essentially of an inclined pipe up which the gold bearing gravel is forced by the action of a powerful stream of water. At the top of the pipe the gravel is deflected into a series of sluice boxes.<sup>3</sup>

The cost of hydraulic mining under favorable conditions is very low. In some gravel beds it is less than three cents per cubic yard.<sup>4</sup>

<sup>1</sup> *Transactions A. I. M. E.*, vol. vi. p. 27, and vol. xxii. p. 325. See also *Engineering and Mining Journal*, vol. xliv. pp. 563-565.

<sup>2</sup> For example, where the flume passes through a cañon, or along the side of a cliff, the earlier usage was to support it by trestles from below. Instead of this the flumes are now suspended from iron brackets inserted in the rocks. The intermittent flow of water, which formerly forced many mines to suspend operations during the dry season, has been remedied in many places by storage reservoirs that keep up a steady supply of water the year around. The price of water has also fallen from 25 cents per miner's inch to 8 cents in some localities.—See *Engineering and Mining Journal*, vol. xlix., pp. 563-565, LOCK, *Practical Gold Mining*, p. 359.

<sup>3</sup> *Transactions A. I. M. E.*, vol. xxii. p. 325. Under some conditions this appliance raises 1½ tons of gravel per minute.

<sup>4</sup> *Transactions A. I. M. E.*, vol. xxii. p. 325.

## IMPROVEMENTS IN VEIN MINING.

The general improvements in this branch of gold mining are similar to those which have revolutionized every department of mining industry. Their application to silver mining has been described in some detail in an earlier article.<sup>1</sup> It will therefore be necessary only to summarize them at this time. They comprise the rapid extension of transportation facilities into mining districts; the use of electricity in lighting, and in operating machinery; improved appliances for hoisting, which have also tended to offset the disadvantages of deep mining; improved construction of ore mills, where the force of gravity is utilized to move the ore; improved samplers and concentrators which have almost entirely displaced hand labor in these operations; roasting furnaces which make that process automatic, and finally great advances in the construction of ore crushers and stamps. The special improvements in machinery and processes require some attention. One of the most important improvements in machinery is the prospecting drill, which enables a sample to be taken of every foot of rock through which it passes. By its use the continuity of the Rand reefs to a depth of 2400 feet has been demonstrated.<sup>2</sup> The machinery used in amalgamation has also been greatly improved. Much of the gold, when separated from its matrix, is so fine as to float away on the surface of the water. The prevention of the resulting waste has presented a serious problem. The most successful methods hitherto employed consist of a series of tables covered with burlap, or coarse sacking, over which the waste material is allowed to flow, the fine gold being caught in the cloth.<sup>3</sup>

The most important special improvements in gold milling have been made in the methods of treating the refractory ores that occur below the perpetual water line. In these, the gold is carried in sulphur or other compounds; and here the application of the ordinary amalgamation process has proved unre-

<sup>1</sup> "The Fall in the Price of Silver since 1873," in this JOURNAL for June 1897.

<sup>2</sup> REUNERT, *Diamonds and Gold in South Africa*, Appendix 20.

<sup>3</sup> LOCK, *Practical Gold Mining*, pp. 229 *et seq.*

munerative.<sup>1</sup> The methods which have proven most successful in dealing with these ores are smelting, chlorination, and the cyanide process. Their importance for this discussion arises from the fact that the recent increase in gold production has come almost entirely from the refractory ores.

In the chlorination process, the ores, if they contain sulphur, are roasted after they come from the stamps. Chlorine gas is then passed through the mass, forming gold chloride, which is soluble in water. The gold is finally precipitated by the addition of sulphate of iron.<sup>2</sup> The tanks in which the chlorination takes place were at first stationary; and the gas was generated outside and admitted from below. This process proved a slow one, and revolving barrels were substituted which greatly accelerated the process. In some cases the ingredients from which the chlorine is generated are placed in the barrel along with the material which is to be treated; and the generation of the gas accelerated by agitation.<sup>3</sup> This improvement dates from the early eighties. The size of the barrel has been enlarged, thus increasing its capacity; and the difficulties of treating the pulp as it comes from the barrel have been reduced by the introduction of a filter.<sup>4</sup> Chlorine gas is now manufactured at central points and shipped in a condensed form to localities where the transportation charges on the raw materials would form a large part of the cost of treatment.<sup>5</sup> During the last few years, the cost of chlorination has been reduced from eight to twelve dollars per ton of the material treated,<sup>6</sup> to three to six dollars per ton.

The cyanide process was first applied on a large scale in 1891.<sup>7</sup> It was first employed to treat the gold bearing material which had been already subjected to the amalgamation process. These "tailings" are first treated with a one-half per cent. solution of potassium, cyanide; then with a 3 per cent. solution; and the gold is finally precipitated by the introduction

<sup>1</sup> FISSSLER, *Metallurgy of Gold*, p. 4.

<sup>2</sup> *Transactions, A. I. M. E.*, vol. xxiii. pp. 338-339.

<sup>3</sup> *Ibid.*

<sup>4</sup> *Ibid.*

<sup>6</sup> *Ibid.*, p. 668.

<sup>7</sup> *Ibid.*, p. 461.

<sup>5</sup> *Engineering Magazine*, vol. xi. p. 669.

of zinc shavings.<sup>1</sup> By this process 75 per cent. of the gold contained in the tailings is extracted, all of which would otherwise be lost if the producer must depend upon simple mercury amalgamation. Electrical precipitation has been introduced where the solution contains copper.<sup>2</sup> The cyanide process has recently been employed to treat the ore direct from the stamps.<sup>3</sup> By this method the labor of handling is greatly reduced, and a larger percentage of gold is saved. One-third of the gold produced in South Africa is now recovered by means of the cyanide process.<sup>4</sup> From October 1891, to October 1894, 1,225,115 ounces were produced by this process in the Rand district.<sup>5</sup>

This long series of inventions, co-operating with the increasing value of gold, have doubtless had the effect of greatly decreasing its absolute cost of production. That is to say, on ores of a richness similar to those which were profitably worked thirty years ago, the percentage of profit from present working has been much increased.<sup>6</sup> With the conditions of 1850 prevailing in 1897, the world's gold production would be a mere fraction of its present amount. The pick and pan of the early day would be helpless in the face of existing conditions. But the progress of

<sup>1</sup> See ROTHWELL, *Mineral Industries*, 1892, p. 239.

<sup>2</sup> In this case the zinc precipitation is imperfect. The electric current is passed through the solution, and precipitates gold on the negative pole and the metalloid at the positive—ROTHWELL, *Mineral Industries*, 1895, p. 339.

<sup>3</sup> Two and one-half tons of stamped ore and one-half ton of cyanide are put into a barrel in which freshly dressed amalgamating plates are set upright. The barrel is made to revolve slowly for an hour. The solution is then poured off and the plates are scraped. The pulp passes on into vats, where it is again treated with cyanide.—*Colliery Engineer and Metal Miner*, May 1897.

<sup>4</sup> *Ibid.*, August 1897.

<sup>5</sup> *Report of the Director of the Mint on Precious Metals in the United States*, 1894, p. 152.

<sup>6</sup> The *Report of the Director of the Mint on Precious Metals in the United States*, 1894, p. 147, gives average cost of production on the Rand at \$6.50 per ton. See also p. 113. Formerly all the sulphides were wasted. The milling of gold has so progressed that it is now possible to work ores which ten years ago, were worthless.

"The cost of gold milling now runs from 30 cents to \$1.60 per ton. These figures are taken from a large number of representative gold mills."—*Colliery Engineer and Metal Miner*, December 1896.

"With the large, low grade ore bodies which are destined to furnish the greater

improvement has steadily depressed the margin of production. Poorer and poorer ores have been successfully treated, so that if we regard the cost of production of gold as an average of the mining expenses of all producers, it is impossible to say that it has declined. On the contrary, it is very doubtful if their advances in methods and machinery, and this general cheapening of the instruments of production have offset the diminishing yield of the sources of supply. The marginal cost of production of gold has undoubtedly risen with its value; for the marginal cost of production of gold over long periods tends to conform to its value.

It appears, therefore, (1) that the lack of correspondence

part of the precious metals in the future, the costs at well located mines and mills may be roughly estimated at \$2 per ton for mining, and \$3 per ton for barrel chlorination, or for treatment by the cyanide process on ores from which 90 per cent. of the metal can be saved."—ROTHWELL, *Mineral Industries*, 1892, p. 224.

"Prior to 1875, mining was limited to ores running not less than \$10 to \$20 per ton for free mining ore; and on refractory ores from \$35 to \$50 per ton."—*Engineering Magazine*, vol. ii. pp. 462-463.

#### MINING COSTS.

ENGINEERING AND MINING JOURNAL, VOL. LIV, P. 132.

Name of mine	Year	Cost per ton
Plymouth Consolidated.....	1884	\$3.89
Homestake .....	1885	3.03
Caledonia .....	1886	2.95
Caledonia .....	1887	3.20
Caledonia .....	1888	3.12
Caledonia .....	1889	2.74
Sierra Buttes.....	1889	3.68
Plumas Eureka.....	1889	3.98

ROTHWELL, *Mineral Industries*, 1895, p. 319.—Milling cost in four representative American districts.

District	Labor	Shoes and Dies	Water	Fuel	Supplies, etc.	Total
Black Hills.....	\$.15	\$.02	\$.20	\$.19	\$.14	\$.70
Gilpen.....	.42	.05½	..	.10	.17½	.75
Grass Valley.....	.32	.09	.31		..	.80
Amador.....	.20	.04½	.17		.04½	.46

between gold production and gold value from 1853 to 1884 was due to the difficulty of transferring the industry from the secondary to the primary forms of deposit; (2) that the decline in production was arrested and finally converted into an advance by the co-operation of three forces, (*a*) an increasing value of gold, (*b*) a progressive advance in prospecting activity, and (*c*) a series of improvements in the methods and machinery of extraction.<sup>1</sup>

#### THE FUTURE OF GOLD.

The transition from placer to vein mining has now been accomplished and the methods of vein mining have been perfected. Hereafter, no decrease of production need be feared between the exhaustion of the placers, and mining of the quartz, nor between the working of the free milling ores and the treatment of the refractory sulphides. When gold is discovered in the future, we may reasonably expect that quartz mining will be at once begun, and that low grade as well as high grade ores will be speedily attacked. This fact argues for greater continuity in the production of gold than has hitherto been the case.<sup>2</sup>

Gold mining in the past has suffered severely from stock speculation. There has been much gambling in the industry, and the resulting waste of capital has been enormous. A large amount of capital has been sunk in some fraudulent mining scheme; the public has been heavily mulcted and the available mining capital absorbed by the "operators." As a result, gold mining investment has come to a standstill. Proprietors of rich properties could not at any premium obtain the capital necessary to develop them. This has acted to diminish production. As the public comes to understand the nature of gold mining, and as the miners resort more and more to the large and uniform bodies of low grade ore, the prizes grow smaller and the attract-

<sup>1</sup> Acknowledgment is due to Mr. H. W. Nichols, curator of the Field Columbia Museum, for valuable assistance in the preparation of this paper.

<sup>2</sup> ROTHWELL, *Mineral Industries*, 1896, p. 248, gives the quartz production of British Columbia in ounces, as follow: 1893, 23,404; 1894, 125,014; 1895, 785,271; 1896, 1,244,180.

iveness of the lottery diminishes. We may therefore expect a decrease of speculation, and a more rational development of gold mining, and this will no doubt act to give the future production greater stability. It is not unreasonable to assume that a continued advance will be made in the machinery and processes of gold extraction. There is still room for great improvement, and the difficulties ahead will doubtless be overcome as those of the past have been. These general considerations afford ground for an optimistic view of the future of gold production.

Let us examine the question more closely from the standpoints of the effect of an increasing demand and the chance of new discoveries. We have seen that the production of gold has been profoundly influenced by its increasing value; and that, in particular, the increased production of the last fifteen years has been to a large extent the result of the great fall in general prices which has characterized this period. The natural inference is that a rise in general prices, which might be conceived to follow the general acceptance of a bimetallic policy by the great commercial nations, would speedily operate to diminish the output. So far as the maintenance of the present annual production depends upon the continuance of the present prospecting activity, such a result might be expected to follow from an advance in prices. A lower value of gold would no doubt lend to lessen the attractiveness of the search for gold. But so far as concerns existing companies and their efforts both in prospecting and in improving methods and machinery, it seems not unreasonable to suppose that a falling value of gold would operate not to weaken, but to intensify these efforts. Gold mining is an industry in which the element of fixed capital is of prime importance. Enormous amounts of capital has taken the form of gold mines and mills. Owing to the general descent to low grade ores,<sup>1</sup> the margin of profit on these investments is not large. The effect of rising prices, or in other words a falling value of gold, would be in many cases sufficient to wipe out this profit or even convert it into a loss. In every

<sup>1</sup> *Engineering and Mining Journal*, vol. lxiv. p. 422.

case the returns on the investment would be lessened. The gold miner would therefore be stimulated to offset this influence by introducing improved processes and machinery, to diminish his expenses by every form of economy, and to develop new sources of supply in the neighborhood of his plant. It is reasonable to assume that the prospect of certain loss would prove a stronger incentive to improvement than the chances of a small additional increment of profit would be, and that falling values therefore tend in some measure to counteract the decrease of production which is generally supposed to follow immediately from a decline in values. This has certainly been true in the case of silver. The well-known increase in inventive activity which follows every panic also gives confirmation to this view. To the extent to which this force might act—and there is reason to believe that its influence would be considerable—a falling value of gold would not decrease its production.

The bearing of this consideration upon the bimetallic claim for a possible concurrent circulation of gold and silver is significant. If a declining value of gold should fail to diminish its supply, there would be so much the less chance that the existing stock and future supply would be absorbed by the industrial demand. By so much, then, the chances of a concurrent circulation the two metals would be improved. On the other hand, if prices continue to fall, the same stimulus to invention and discovery that has so strongly influenced gold production the past thirty years will continue to operate. If the world will pay the price, it can, no doubt, obtain gold in increasing amounts.<sup>1</sup>

It remains to indicate the possibilities of the opening of new deposits. Of the gold producing countries, it is to be said, the United States and much of Australia have been thoroughly prospected, and wherever gold is found in these regions, mining activity immediately begins. We are chiefly concerned with those districts in which gold is known to exist, but which have not yet been exploited to any considerable extent. It is to these regions that we must look for the future supplies of gold.

## AFRICA.

The most promising gold fields are found in South Africa, principally in the Transvaal. The gold in this region occurs in zones rather than veins, and there are no placers.<sup>1</sup> The occurrence of gold is in conglomerate beds—masses of rounded quartz pebbles set in cement. The original formation was undoubtedly placers, but these were subsequently overlaid with other formations and solidified by heat and pressure. After these beds had been laid down horizontally, they were disturbed by volcanic action, and tilted in every direction; but the original strata have been preserved throughout. All the evidence points to the continuity of these beds throughout the district. The regularity of the deposit indicates that the gold-bearing strata run very deep.<sup>2</sup> The regularity of the South Africa reefs is of great importance for their yield, since it offers the prospect of a steady return to mining investment. The Rand reefs have been exposed for a distance of thirty miles and are at least one mile wide. The main series of reefs have been traced for a distance of 150 miles, and have been pierced by drills at a deposit of 2400 feet.<sup>3</sup> Bergrath Schmeisser<sup>4</sup> contends that on the estimate of a working depth of 800 meters, the supplies of gold on the Rand would amount to \$1,020,828,355. If the depth is assumed to be 1200 meters, the supply would be \$1,710,506.00. Hamilton Smith corroborates this estimate.<sup>5</sup> He holds that the Rand reefs are continuous and that they will produce £325,000,000. These estimates are countenanced by the regularity of the

<sup>1</sup> *Transactions A. I. M. E.*, vol. xviii. p. 335.

<sup>2</sup> ROTHWELL, *Mineral Industries*, 1892, pp. 204 *et seq.*

<sup>3</sup> REUNERT, *Diamonds and Gold in South Africa*, pp. 97, 98, 103. See also ROTHWELL, *Mineral Industries*, 1893, p. 315. *Engineering and Mining Journal*, vol. lxiii. p. 659.

<sup>4</sup> *Ueber Vorkommen und Gewinnung der nutzbaren Mineralien in der Südafrikanischen Republik*. A portion of this is reprinted in the *Report of the Director of the Mint on Precious Metals in the United States*, 1894, p. 118.

<sup>5</sup> Hamilton Smith is an American mining engineer who made a report in 1893 on the Rand district, to the London House of Rothschild. His report was revised in 1894, and reprinted in *Report of the Director of the Mint*. *Ibid.*, 1894, p. 163.

deposits. They assign the reefs an extreme length of between ten and twelve miles.

Similar gold deposits occur in other parts of the Transvaal.<sup>1</sup> In the DeKaap district the quartz is especially rich, and beds of conglomerate also occur in the eastern, northwestern, and western portions of the country. Similar beds are found in Cape Colony, in Zululand, in Matabele and Mashona land, and in the Orange Free State.<sup>2</sup> On the west coast, besides extensive alluvial deposits, there are large beds of the same conglomerate formation that occurs in South Africa.<sup>3</sup> Madagascar is also reported to contain gold in large quantities, but this country has not been thoroughly prospected.<sup>4</sup>

#### AUSTRALASIA.

The gold fields of western Australia have been already referred to. Unworked deposits of great richness occur in New South Wales.<sup>5</sup> In New Zealand are important deposits which have not been touched. The province of Otago is especially rich in gold.<sup>6</sup>

#### ASIA.

Valuable gold deposits are known to exist in southeastern Asia, both on the continent and the islands.<sup>7</sup> Considerable

<sup>1</sup> REUNERT, *Diamonds and Gold in South Africa*, p. 118.

<sup>2</sup> *Transactions, A. I. M. E.*, vol. xviii, p. 335. See also, REUNERT, *ibid.*, p. 118, Appendixes XII, XIII, XIV, XV, XVI, XVII, and XVIII.

<sup>3</sup> *Engineering and Mining Journal*, vol. li, pp. 323, 324. See also, *Annual Report on the Gold Coast*, reprinted in *Report of the Director of the Mint, ibid.*, 1894, p. 169.

"I doubt very much whether California ever presented to the naked eye the tempting wealth of gold which so forcibly attracts the attention of the traveler in the western districts of the Gold Coast."—*Ibid.*, p. 170; an extract from a paper by Mr. Hesketh Bell, F. R. G. S., Assistant Treasurer of the Gold Coast.

<sup>4</sup> *Engineering and Mining Journal*, vol. lxii. p. 122.

<sup>5</sup> *Report of the Director of the Mint, ibid.*, 1894, p. 194.

<sup>6</sup> "The extent of the gold-bearing alluvium lying among the highlands of this province is imperfectly known, but so far as it has been explored all facts point to the conclusion that it is enormous."—*Transactions, A. I. M. E.*, vol. xxi. p. 428.

<sup>7</sup> *Engineering and Mining Journal*, vols. liii. p. 409; lviii. p. 409; lxii. p. 337; liv. p. 196.

deposits are located in the Japanese archipelago.<sup>1</sup> The production of southern India has increased during recent years, and important discoveries have been made in that region.<sup>2</sup> Russian exploration in Thibet shows the existence of extensive gold fields, which, so far as is known, comprise about ninety square miles.<sup>3</sup> Gold is also found in Manchuria,<sup>4</sup> and large amounts of quartz are located in eastern Siberia, which have not been worked to any extent.<sup>5</sup> Gold occurs in large quantities in northern Asia Minor.<sup>6</sup>

#### EUROPE.

The Ural mountains contain large amounts of quartz. The ore of these deposits generally consists of low grade sulphides.<sup>7</sup>

#### SOUTH AMERICA.

Uruguay contains considerable quantities of gold deposit, particularly on the Brazilian frontier<sup>8</sup> and in spite of the long

<sup>1</sup> Report of the Director of the Mint, *ibid.*, 1894, pp. 243, 244.

<sup>2</sup> ROTHWELL, *Mineral Industries*, 1892, p. 197. See also, *London Economist*, Jan. 11, 1896.

<sup>3</sup> *Engineering and Mining Journal*, vol. liii. p. 661; vol. xl ix. p. 113; and vol. xxiii. p. 41.

<sup>4</sup> *Engineering and Mining Journal*, vol. lxiv. p. 455.

<sup>5</sup> "So far as the Siberian gold fields, which furnish the greater part of the production, are concerned, it may be said that the work already done is entirely superficial. Only the placers have been worked, and these generally in a rather primitive way, while explorations have been, on the whole, limited to the haphazard work of prospectors. Deep mining is almost unknown."—*Engineering and Mining Journal*, vol. lxii. p. 434.

"The deposits of the Nerchinsk district, Amour region, and Yakutsk province, are distinguished for their richness, continuity, and considerable extension. In general the richness of the gold deposits of the rivers, Amur, Lena, and their tributaries, shows itself in every respect, beginning with the width, size of stratification, and the amount of gold they contain. . . . They are from four to six feet thick and are very uniform in their formation without any faults."—*The Industries of Russia*, published for the World's Columbian Exposition, vol. iv. pp. 12-13. See also, ROTHWELL, *Mineral Industries* 1895, p. 659.

<sup>6</sup> *Engineering and Mining Journal*, vol. xxiv. p. 423.

<sup>7</sup> *Engineering and Mining Journal*, vol. xliv. p. 363. See also, *The Industries of Russia*, vol. iv. pp. 12, 13, 15; and DAVIES, *Metalliferous Metals and Mining*, p. 35.

<sup>8</sup> *Engineering and Mining Journal*, vol. l. pp. 244-245. See also *Handelsarchiv*, December 1891.

continued production of Brazil, that country is still rich in gold.<sup>1</sup>

Deposits of very large extent are situated in Bolivia, which have not been worked to any considerable extent. Bolivia has two main gold belts; one beginning in the northwest and extending southeast, the other begins in the southwest, extends east, then northeast, and finally joins the northern belt. Large deposits also occur in the main range of the Andes, in the extreme north.<sup>2</sup> In the eastern part of Peru gold occurs in large quantities; both quartz and placer deposits being found.<sup>3</sup> In Ecuador, there are extensive quartz deposits and also large amounts of gravels so situated that they may be economically operated by the hydraulic process, with abundance of water, high dumps and swift streams to carry away the débris.<sup>4</sup> Columbia has produced, since the Spanish conquest, \$700,000,000 of gold; almost entirely without machinery. The departments of Antioquia, Cauca, and Tolima are very rich both in placer and quartz deposits.<sup>5</sup> The

<sup>1</sup> Deposits of large extent are found throughout a great part of Minas Geraes, and in the states of Goyaz, Western Bahia, Maranhao, Matto Grosso, and So Paulo. In 1892 there were only four deep mines in operation in this region. In the vicinity of Minas Geraes the pyritic ores are very rich.—*Engineering and Mining Journal*, vol. liii. p. 277. See also *ibid.*, vol. i. p. 239. A large part of these deposits are composed of laterite. “This is the product of physical and chemical changes in the rocks due to atmospheric agencies under a tropical climate. Veins of quartz pass into this without change of direction or thickness; but the whole mass is so soft that it can be easily crushed between the fingers. Much of this contains gold and the deposits are of vast extent and hundreds of feet in thickness.” See also PHILLIPS’ *Ore Deposits*, pp. 613–616.

<sup>2</sup> Report on the *Gold Mines of Bolivia* by MINISTER ANDERSON of La Plata, contained in *Special Mint Report on Production of Gold and Silver in the United States, 1891*, pp. 102–106.

<sup>3</sup> Large gold-bearing alluvial deposits are found in the Eastern Cordilleras and in the northern region. In the department of Loreto, in the province of Alto Amazonas, many alluvial deposits occur. These were worked for two centuries, but were abandoned in 1867 owing to the attacks of Indians. In the province of Loja large quartz deposits are in sight. The provinces of Pataz and Otuzco are very rich in gold. The streams in the former are uniformly gold bearing.—*Engineering and Mining Journal*, vol. li, p. 71.

<sup>4</sup> *Engineering and Mining Journal*, vol. lviii. p. 532.

<sup>5</sup> In the province of Antioquia, which now produces between three and four million dollars each year, the quartz deposits are exceptionally rich, and a compara-

placers of Venezuela are of considerable extent, and large ore deposits are also found.<sup>1</sup> In British and Dutch Guiana very important deposits occur, and these are being rapidly developed. Only the crudest appliances have hitherto been employed.<sup>2</sup>

#### NORTH AMERICA.

In Central America, Nicaragua, Costa Rica, and Honduras, there are large deposits, both in quartz and in placers.<sup>3</sup> In Mexico, rich deposits occur in the northwestern, middle western, and southern states. The gold ores of Mexico are generally low grade.<sup>4</sup> Passing to Canada, we find that Nova Scotia contains considerable deposits of quartz as well as rich placers.<sup>5</sup> Extensively small portion has been worked. In the north of this province are vast areas of alluvial deposits which have only been skimmed over. The beds of gold-bearing gravel in the department of Cauca are very extensive. Beds of cement, rich in gold, are also found. Since the abolition of slavery in 1857, the mines in this district have been practically abandoned. In the northeastern part of the province, a district of between 800 and 1000 square miles is covered with glacial drift, much of which is gold bearing.—ROTHWELL, *Mineral Industries*, 1895, p. 634. See also *Engineering and Mining Journal*, vol. liv. p. 377; and *Engineering Magazine*, vol. iv. p. 605.

<sup>1</sup> *The United States of Venezuela. Official Publication for the World's Columbian Exposition*, p. 15. See also *Engineering and Mining Journal*, March 24, 1888.

<sup>2</sup> "From Baruna to Cuini, where identically similar evidences as to placers, and external evidences at least as to a continuous vein of mineral are found, there exists an area of country which will rank in the future with the richest gold producing sections in the world."—*Engineering and Mining Journal*, vol. lxii. p. 30. See also for Guiana, *Handelsarchiv*, August 1891, p. 507; *London Economist*, March 10, 1894; and *Report of the Director of the Mint on Precious Metals in the United States*, 1894, pp. 238-242.

<sup>3</sup> *Engineering and Mining Journal*, vol. liii. p. 277; *Transactions A. I. M. E.*, vol. xx. p. 409; ROTHWELL, *Mineral Industries*, 1896, p. 799; *Report of the Director of the Mint*, 1897, *ibid.*, pp. 252-256.

<sup>4</sup> "Some gold deposits occur in the Sierra Madre. The districts around Oaxaca are very rich in gold," *ibid.*, vol. lviii. p. 107. "The gold belts of Zacatecas is 250 miles long and 100 miles wide. Throughout this district gold-bearing quartz, much of it rich, is found in great abundance." "In Sonora are many silver-gold and gold mines." "In the western portion of Prietas and extending into Sonora is a district which abounds in gold veins, though few of them have been worked to a profit." "North of Alamos are rich deposits." "Near Batopilas in Chihuahua, rich gold deposits were discovered in 1887." "Many rich deposits and mines exist in Durango."—*Ibid.*, vol. lv. p. 74. *Engineering and Mining Journal*, vol. xlix. p. 131.

<sup>5</sup> *Geological Survey of Canada, Division of Mineral Statistics and Mines, Annual Report for 1890*, pp. 55, et seq.

sive deposits of both kinds exist in Quebec.<sup>1</sup> Ontario is also rich in gold.<sup>2</sup> The deposits of British Columbia are of great richness. In the Cariboo district extensive placer deposits are found together with rich quartz veins. Large amounts of "drift" deposits are also found. In the Rossland district, large amounts of low grade ore have been worked within the past three years, and in other portions of the province gold is also found in considerable amounts.<sup>3</sup> Finally, the last two years have witnessed extensive gold discoveries in Alaska; and here the indications point to the existence of very large deposits.<sup>4</sup>

The mere enumeration of the localities where gold is yet to be extracted in large quantities, shows the difficulties which stand in the way of the gold miner in these districts. Most of these deposits are situated in barbarous or half-civilized countries, where life and property are insecure. Capital avoids these countries, and yet without large investment of capital progress in gold mining is an impossibility. From some of the richest deposits, those of Russia and China, private enterprise has hitherto been excluded. Climatic difficulties also retard the development. The deposits of the gold coast of Venezuela and the Guianas, for instance, are situated in damp unhealthy districts, and the native labor is in most instances extremely untrustworthy and inefficient. The extreme cold of Siberia and Alaska greatly hinders the development of their gold resources.

<sup>1</sup> "The Beauce auriferous region covers a very extensive area, estimated at 15,000 square miles. Nearly all the river beds of this district contain gold. Numerous quartz veins exist nearly everywhere. The gold-bearing ore is not of a particularly high grade."—J. OBALSKI, *Mines and Minerals of Quebec*, p. 56, *et seq.*

<sup>2</sup> *Engineering and Mining Journal*, July 3, 1897. Mr. T. A. Rickard states that extensive gold deposits appear to be located in the Lake of the Woods District. See also *World's Columbian Exposition Catalogue of Mineralogical Exhibits: Ontario*.

<sup>3</sup> For British Columbia, see *Provincial Bureau of Mines, Bulletin No. 2, Colliery Engineer and Metal Miner*, October 1895; *ibid.*, July 1897; and *Transactions A. I. M. E.*, February 1897.

<sup>4</sup> For a discussion of these fields, see the *Engineering and Mining Journal*, vol. lxiv. pp. 422, 425, and 455. See also, WILLIAM OGILVIE, *Information Respecting the Yukon District*.

Perhaps the most serious difficulty is the inaccessibility of the deposits. In hardly any of the districts mentioned can the mines be reached by railroad, or water transportation. This is an almost insurmountable obstacle to their development. Without transportation, only placers and high-grade free milling ores can be worked.

We have no reason to suppose that these conditions will long continue. The rapid advance of civilization in all quarters of the world bids fair to eliminate most of them in the early future, and when these problems are solved there can be no doubt that the world's gold supply will be enormously increased. It should be remembered that only two districts, California and Australia have been thoroughly explored, and yet even their yield shows no signs of diminution. The great number of deposits which have not been touched, and the still greater number where mining has been of the most superficial character, leave no ground for the opinion that the world's gold supply will be seriously contracted for an indefinite future. The development of these regions will be more rapid if the fall of general prices continues and the profits of gold production increase.

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